4-2019

Food Neophobia in Children and the Role of Sensory Characteristics of Food

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A thesis submitted in partial fulfillment of the requirement
for the degree of Bachelor of Arts in Psychological Sciences from
The College of William and Mary

by

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Accepted for Honors
(Honors, High Honors, Highest Honors)

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April 24, 2019

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Acknowledgements

I would like to thank my advisor, Dr. Catherine Forestell, for the knowledge, guidance, and support she has provided me throughout this project. I would also like to thank my committee members, Dr. Elizabeth Raposa, Dr. Meghan Sinton Miller, and Dr. Robert Scholnick, for taking the time to be on my defense committee and for providing their feedback. Additionally, thank you to the Roy R. Charles Center for Academic Excellence for providing funding for this project. Without this funding and the contributions of my gracious donors, this project would not have been possible. Finally, I would like to thank Emily McManus, Jonathan Russell, and Repairer Etuk for assisting with this study.

Abstract

This research study examined the effects of color, texture, and odor on vegetable acceptance in children who ranged in their food neophobic tendencies. Seventy nine children ages three to six years completed a behavioral task in which the color (yellow or green), texture (blended corn or kernels of corn), and orthonasal odor (no added odor or green vegetable odor) of cream-based vegetable soup (corn chowder) samples were manipulated in a repeated measures design. Overall, children rated the yellow samples more positively than the green samples prior to trying them. They also consumed more of the samples that were yellow than those that were green, more of those without an added odor than those with a green vegetable odor, and marginally more of those that were chunky than those that were smooth. Moreover, the effects of the sensory characteristics appeared to be additive; children consumed less of the samples that contained at least two of the unliked sensory characteristics relative to those that did not. Children who were neophobic rated the samples more negatively and consumed less of the soup overall compared to non-neophobic children. Neophobic children were also less willing to try the samples than the non-neophobic children overall, with the exception of the green, chunky samples. In contrast non-neophobic children ate significantly more of the yellow, chunky soup relative to the other samples. These results suggest that children incorporate familiar sensory cues into their food-related schemata and utilize them when determining whether to try novel foods.

Keywords: neophobia, sensory aspects of food, vegetable acceptance

Food Neophobia in Children and the Role of Sensory Characteristics of Food

Parents often struggle to feed their children adequate amounts of fruits and vegetables (Siega-Riz et al., 2010). This is of considerable concern given the high prevalence of childhood obesity, which is associated with the early development of non-communicable diseases, such as type 2 diabetes (Hannon, Rao, & Arslanian, 2005). Encouraging food neophobic children to consume adequate amounts of fruits and vegetables is especially challenging for parents (Cooke, Carnell, & Wardle, 2006). Food neophobia (referred to as "neophobia" from this point forward), is the degree to which children hesitate to try new foods (Dovey Staples, Gibson, & Halford, 2008) and it peaks between two and six years of age (Addessi, Galloway, Visalberghi, & Birch, 2005; Cooke, Wardle, & Gibson, 2003). The degree to which children display neophobic behaviors may be related to parental neophobia (Cooke, Haworth, & Wardle, 2007), as well as child temperament (Pliner & Loewen, 1997). Because young children's neophobic eating behaviors primarily involve the rejection of healthy items like fruits and vegetables (Johnson, Davies, Boles, Gavin, & Bellows, 2015; Nicklaus, Boggio, & Issanchou, 2005), more research is needed to understand the factors associated with neophobic children's hesitancy to consume them (Dovey et al., 2008).

Research suggests that sensitivity to sensory stimuli is associated with selective eating or neophobic eating patterns in toddlers and preschool age children (Farrow & Coulthard, 2012; Johnson et al., 2015; Monnery-Patris et al., 2015). For example, prior work in this area indicates that children's taste and smell sensitivity is associated with lower overall consumption and consumption of a narrow range of fruits and vegetables (Coulthard & Blissett, 2009). Children who are more sensitive to the feel of various general tactile stimuli are also more selective in their eating (Coulthard & Thakker, 2015; Nederkoorn, Jansen, & Havermans, 2015; Smith, Roux, Naidoo, & Venter, 2005), possibly because of an increased sensitivity to oral tactile stimulation. This suggests that in addition to taste and smell sensitivity, tactile sensitivity might play a role in the acceptance of food and may partially explain why neophobic children are reluctant to try novel foods. While sensory sensitivity is an intrinsic characteristic of the child, foods vary drastically in their sensory characteristics. Although fruits and vegetables range in their flavor characteristics, certain common sensory characteristics, such as bitter taste, high astringency, or sulfurous volatiles (Bett, 2002), may reduce children's acceptance of green vegetables (Bell & Tepper, 2006; Turnbull & Matisoo-Smith, 2002).

When a child is deciding whether or not to try a novel food, visual characteristics are salient and important cues (Dovey et al., 2012). According to a review by Dovey and colleagues (2008), children may develop cognitive schemata about how foods should look; when certain foods are inconsistent with these schemata, children may be deterred from trying them. This would suggest that if a food has an odd or atypical appearance, children, especially those who are neophobic, may be less likely to try it. However, research suggests that this may not always be the case. For example, in one study, children expected to like vegetables with an atypical color *more* than those with a typical color (Poelman & Delahunty, 2011). However, upon tasting, these evaluations changed and the typicality of color did not affect liking. Thus, atypical colors may encourage children to try new foods, but they may not be sufficient for increasing consumption of a novel food.

Although visualizing certain aversive food textures has been shown to elicit strong disgust reactions (Martins & Pliner, 2006), and disgust reactions play a role in the rejection of novel food items in adults (Martins & Pliner, 2005), little research has investigated whether visually perceived textures play a role in children's rejection of novel foods. However, some research has investigated the relationship between children's touch exposure to novel foods and their subsequent willingness to try them. In two studies, children were asked to hold either a novel vegetable (Coulthard, Palfreyman, & Morizet, 2016) or fruit (Dovey et al., 2012) in their hand and rate it based on the degree to which it felt "nice" or "strange"; however, these tactile ratings did not predict children's willingness to try the food in either of these studies. Much of the research in this area has been conducted on the role of oral texture in children's hedonic ratings (Donadini, Fumi, & Porretta, 2012; Zeinstra, Koelen, Kok, & de Graaf, 2010) and acceptance of foods (Werthmann et al., 2015). Studies have shown that the toughness (Donadini et al., 2012) and granularity (Zeinstra et al., 2010) of vegetables is inversely related to liking.

Given the volatility of odors, children may also make decisions about whether to try a food based on its olfactory properties. In fact, some research suggests that it is primarily the olfactory qualities of a food, rather than its appearance, that may determine whether a child tries it. Coulthard et al. (2016) found that willingness to try a novel vegetable was related to the degree to which children thought the vegetable smelled "strange." Interestingly, this effect appeared to follow a developmental trajectory; while older children thought the novel vegetable smelled more "strange," younger children were more likely to say that it looked "strange." This may be partially because children's abilities to identify odors are weak when young and improve as they age (Sorokowska et al., 2015).

Although several studies have investigated the degree to which visual, tactile, and olfactory characteristics are associated with children's willingness to try and accept fruits and vegetables, little research has investigated the individual and interactive roles these factors may play for neophobic and non-neophobic children. The goal of the current study was to address this gap in the literature by designing a study similar to that of Werthmann et al. (2015). By manipulating the texture, taste, and color of a well-liked fruit yogurt, Werthmann et al. (2015) investigated the role these sensory factors played in children's acceptance, as well as the degree to which children's acceptance was related to their fussy eating habits. They found that children's fruit yogurt acceptance was affected by the texture manipulation, but not by color or taste. However, no significant correlations were seen between behavioral responses to the task and parental reports of children's food fussiness.

To expand upon the work by Werthmann et al. (2015), the primary aim of this study was to examine both the individual and interactive effects of manipulated color (yellow vs. green), texture (smooth vs. chunky), and odor (no added odor vs. green vegetable odor) characteristics on three to six year-old children's responses to cream-based vegetable soup samples. We measured children's hedonic ratings prior to trying the samples, their willingness to try the samples, and their consumption of the samples as assessed by the number of spoons they accepted. Based on previous literature (Coulthard et al., 2016; Dovey et al., 2012; Werthmann et al., 2015), we hypothesized that all three characteristics would influence children's responses to the samples. Furthermore, we predicted that children who were neophobic would rate the samples more negatively, be less likely to try them, and accept fewer of the spoons than non-neophobic children, and neophobic children would be especially wary of samples that were green in color, chunky, and had a green vegetable odor. To our knowledge, the present study is the first to experimentally manipulate the color, texture, and odor of vegetable samples using a controlled factorial design that allowed for the examination of the main and interactive effects of these sensory characteristics as a function of neophobia in children.

Method

Participants

Seventy nine children between the ages of three and six years and their parents were recruited from local schools and recreational camps through flyers and Internet postings. Interested parents were asked to fill out a screening questionnaire to determine if their children had any food allergies or health conditions that would render them unable to participate. If the child was eligible, a session was scheduled for the parent and child to visit the laboratory facility.

Design

A behavioral task was designed to assess how the manipulation of the visual characteristics of color and texture and the orthonasal odor of the food samples would influence children's willingness to try and consume them. A within-subjects 2x2x2 design was used to determine the relative and interactive effects of these three sensory attributes on children's responses. During the task, researchers held a spoon of each sample in front of the child's face and asked the child to "look and smell" before indicating his or her hedonic rating prior to tasting using a three point facial hedonic scale. Children were asked to indicate if they thought the sample would taste "yummy," "yucky," or "in the middle." Afterwards, they were given the opportunity to try the sample and feed themselves. As described below, care was taken to ensure that the flavor (with the exception of the texture) of the samples did not differ as a result of the sensory manipulation. Children were allowed to continue eating if they so desired, and the number of spoons consumed was recorded. This procedure was repeated until the child was given the opportunity to evaluate and taste all eight samples.

Test Stimuli

Food stimuli. Eight samples of Augason Farms Corn Chowder were prepared for each participant. To achieve a 2x2x2 design, the samples varied by color, texture, and odor, with two levels of each factor. Samples were either a baseline yellow (Y) or a green (G) color, which was achieved by adding a drop of green food coloring. They were either blended smooth (S) or had a chunky texture (C) with kernels of corn added to them. Lastly, samples either had no added odor (N) or a green vegetable odor associated with them (O), as described below. Thus, there were eight samples, four of which were yellow and the other four of which were green; of these, half were smooth and the other half were chunky, and of each of these, one did not have an odor added and the other had the green vegetable odor added.

The soup was portioned into eight two-ounce sample cups for each child. Each sample cup contained approximately 20 grams of soup. To ensure that chunky samples contained multiple visible chunks, four grams of rinsed and drained canned corn was added to each cup to achieve the 20 grams. To control for taste, an equal amount of corn was blended into the smooth samples.

Children were presented with the eight samples in one of five different orders. For each of these orders, the no-odor and odor samples alternated to ensure children did not habituate to the green vegetable odor. Seven children were presented with samples in random order (i.e., no-odor and odor samples did not necessarily alternate); however, no significant difference in consumption of the odor samples was observed between these children and those who received alternating samples ($p > .70$).

Odor stimuli. A single a priori unpleasant food odor (2-isobutyl-3-methoxypyrazine) was chosen for this study. This odor, described as “green vegetables,” has been used in previous research examining children's reactions to food odors (Monnery-Patris et al., 2015; Wagner et al., 2014; Wagner et al., 2013). Two microliters of a solution of 2-isobutyl-3-methoxypyrazine (0.5 microliters in 10 milliliters of mineral oil) was applied to a small sticker on the base of the handle on the underside of half of the spoons. We chose this location because there was minimal risk that the child could touch or see the sticker there.

To assess the green vegetable odor, an adult panel consisting of 10 healthy participants (7 female; M = 20.8 y, SE = .49) was recruited. Participants were asked to identify the odor of two samples; one without the green vegetable odor added (no-odor sample) and one with the green vegetable odor added (odor sample). Based on work by Schmidt and Beauchamp (1988), "peppers" or "green vegetables" was scored as a correct response, and "spicy" (a characteristic of green peppers) was scored as a somewhat correct response. Eighty percent of participants correctly or somewhat correctly identified the odor of the odor sample, and 70 percent of participants identified the no-odor sample as distinct from the odor sample.

Questionnaires

Food Neophobia Scales. The Food Neophobia Scale (Appendix A) is a widely used self-report measure designed to assess adults' reluctance to try novel foods (FNS; Pliner & Hobden, 1992). The questionnaire includes ten items, such as, "I don't trust new foods," and "I am afraid to eat things I have never had before." Parents recorded their responses on a seven point Likert scale, and some items were reverse coded so a higher score reflected greater neophobia. Cronbach's alpha for this scale (0.88) indicates good internal consistency, and Pliner and Hobden (1992) reported test-retest reliability as satisfactory. Parents also completed a child version of this scale that was adapted from the adult version (Pliner, 1994) (Appendix B). This scale included only the six items that pertained to young children, such as, "My child does not trust new foods," and "My child is afraid to try new foods" (Wardle, Carnell, & Cooke, 2005). Parents responded using a five point Likert scale.

Food Frequency Questionnaire. Parents completed a food frequency questionnaire regarding their child's vegetable consumption (Appendix C). Consumption of a wide variety of vegetables was assessed (Appendix D), including dark leafy greens and cruciferous, marrow, and root vegetables. Using methods from Wardle et al. (2005), frequency of consumption was recorded using a ten point scale ranging from 0, *never*, to 9, *more than once a day*. Parents indicated if their child liked the vegetable, how often they offered the vegetable to their child, and how often their child typically accepted the vegetable (willingly tried it without pressure to consume). Parents of a subset of children (n = 48) were also asked how often they offered their child cream-based soups.

For analyses, vegetables were broken down into two categories: cruciferous and green vegetables. Cruciferous vegetables included arugula, broccoli, Brussels sprouts, cabbage, cauliflower, collard greens/kale, and turnips. Green vegetables included asparagus, green beans, and spinach. The proportion of vegetables listed that the child had ever tried was calculated separately for cruciferous and green vegetables. Scores of acceptance were converted to reflect weekly consumption of each vegetable. Total weekly consumption scores for cruciferous and green vegetables were then also computed.

Procedure

This study was approved by the Protection of Human Subjects Committee at the College of William & Mary. Because children were consuming corn chowder during this study, sessions were scheduled between the hours of 11 a.m. and 7 p.m. so children felt it was an appropriate time of day to be eating soup. To control for hunger, parents were asked to not feed their children for at least an hour before arriving at the center for testing. Upon arrival, informed consent was collected from each parent prior to participation. After indicating their degree of hunger or satiety using a pictorial scale, children participated in the behavioral task. Upon completion of the task, the researcher recorded the child's height, weight, and the time that the child last ate. Once all questionnaires were completed with the parent, the parent received monetary compensation and children received a toy.

Data Analysis

To assess relationships between child neophobia, parental neophobia, children's vegetable consumption, child age, and BMI, Pearson correlations were conducted.

We then divided children into tertiles based on their neophobia score and in all subsequent analyses, those who were highly neophobic (top tertile cut-off = 3.66) were compared to those who were non-neophobic (bottom tertile cut-off = 2.55). Based on this categorization, we compared children's hedonic responses prior to trying the samples. Hedonic responses to samples were coded as 1, *yucky*; 2, *in the middle*; or 3, *yummy*. For those children who responded between the categories, coding was adjusted accordingly. A four-way mixed analysis of variance (ANOVA) examining color, texture, and odor as repeated measures factors and child neophobia as a between-subjects factor was conducted to explore these differences among children's hedonic ratings of the samples before trying. We then conducted a series of Chi-Square analyses to determine whether children who were neophobic differed from those who were non-neophobic in their willingness to try the samples.

Finally, we conducted a four-way mixed ANOVA with color, texture, and odor as repeated measures factors and child neophobia as a between-subjects factor to investigate differences among the number of spoons children were willing to consume per sample. Due to a large proportion of children who refused to try samples, these data were significantly skewed. Therefore we transformed the data by taking the log of the number of spoons accepted and adding 1. Means reported are log transformed; however, the figures reflect the non-transformed means.

Results

Of the 79 children (36 girls) who participated in the study, five were not included in the analyses because they did not comply with experimental protocol (*n* = 2) or they had a respiratory illness (*n* = 3). The remaining 74 children were close to 5 years of age on average (*M* = 4.81 y, *SE* = .12), and had an average BMI of about 14 kg/m^2 (*M* = 14.31, *SE* = .16). The racial background of the participants was 73.0% White, 1.4% Black, 1.4% Asian, and 24.3% mixed race, and of these 6.8% were Hispanic or Latino. Of the subset of parents who were asked (*n* = 48) whether they had ever offered their children cream-based soups, more than half (54.2%) indicated that they had never offered this to their children, and of those who had, 72.7% indicated that they offered this food infrequently.

As shown in Table 1, child neophobia was significantly negatively correlated with the proportion of cruciferous and green vegetables children had tried and the frequency with which the children consumed these vegetables on a weekly basis. Furthermore, scores of parental neophobia were positively correlated with child neophobia scores, and negatively correlated with measures of child vegetable consumption. Child neophobia was not correlated with either child age or BMI.

Table 1.

	Mean	SD	N	1	2	3	4	5	6	7
Child Neophobia	3.15	1.11	74	0.19	0.07	-0.51**	-0.27*	-0.58**	-0.47**	0.28*
1. Age	4.81	1.06	74		-0.07	0.01	-0.01	-0.21	-0.15	0.02
2. BMI	14.31	1.35	74			-0.08	-0.12	-0.07	-0.01	-0.1
Proportion Vegetables Tried										
3. Cruciferous Vegetables	0.57	0.25	74				0.48**	0.62**	0.41**	-0.47**
4. Green Vegetables	0.84	0.27	74					0.35**	0.48**	-0.26*
Weekly Consumption										
5. Cruciferous Vegetables	2.86	2.41	74						0.64**	-0.36**
6. Green Vegetables	2.47	1.87	74							-0.32**
7. Parental Neophobia	2.6	1.09	73							

Pearson correlations conducted to assess relationships between child neophobia and other variables of interest. A single asterik indicates $p < .05$; two asteriks indicate $p < .01$.

Children's Hedonic Ratings of the Samples

When we analyzed children's hedonic ratings of the samples, which were assessed before they tried the samples, we found a main effect of neophobia, $F(1, 49) = 5.85$, $p < .02$, $\eta^2 = .11$, with neophobic children rating samples less positively ($M = 1.57$, $SE = .13$) than non-neophobic children ($M = 2.04$, $SE = .14$). There was also a main effect of color, $F(1, 49) = 5.44$, $p < .03$, $\eta^2 = .10$, such that children rated yellow samples more positively ($M = 1.87$, $SE = .10$) than the green samples ($M = 1.74$, $SE = .10$).

Children's Willingness to Try the Samples

Chi-square analyses revealed significant differences between neophobic and non-neophobic children's willingness to try the samples. As shown in Figure 1, neophobic were less willing to try the yellow, smooth, odor (YSO; X^2 (1, $N = 53$) = 3.8, $p = .05$) and no-odor (YSN; X^2 (1, 53) = 4.21, $p < .05$) samples relative to the non-neophobic children. Similar results were found for the yellow, chunky samples (YCO; X^2 (1, $N = 53$) = 4.83, $p < .03$ and YCN; X^2 (1, $N = 52$) = 4.74, $p < .03$) and the green, smooth samples (GSO; X^2 (1, 52) = 5.47, $p < .02$ and GSN; X^2 (1, 53) = 4.57, $p < .04$). However, neophobic children were just as willing to try the green, chunky samples compared to non-neophobic children, (GCO; X^2 (1, 53) = 1.65, p = .20 and GCN; X^2 (1, 53) = 1.91, p = .17).

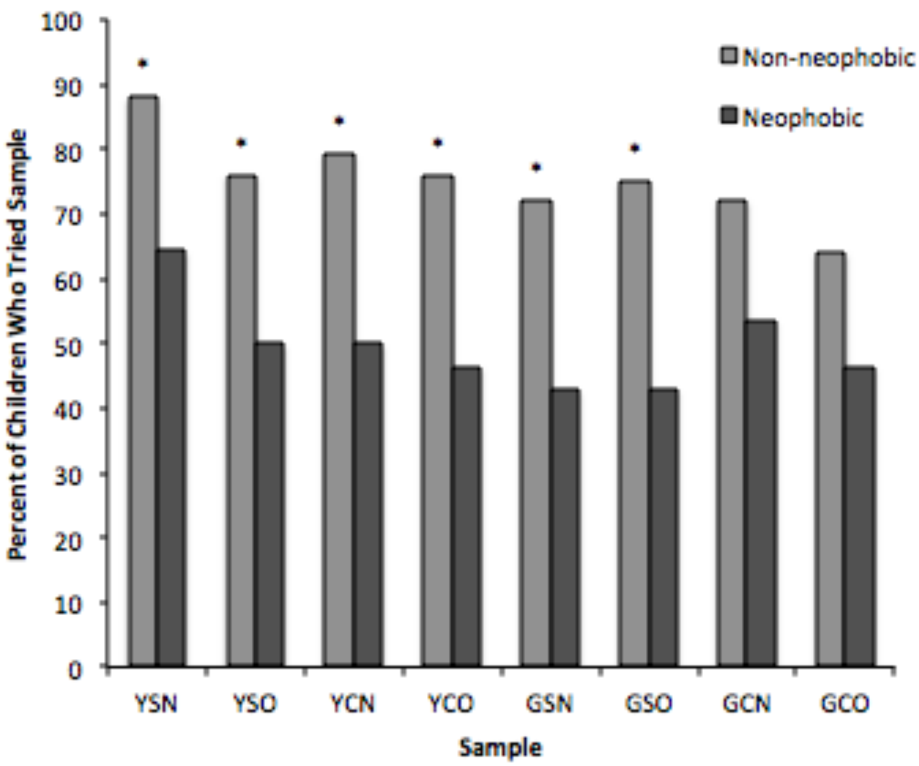


Figure 1. Percentage of children who tried each sample (yellow, smooth, no-odor (YSN); yellow, smooth, odor (YSO); yellow, chunky, no-odor (YCN); yellow, chunky, odor (YCO); green, smooth, no-odor (GSN); green, smooth, odor (GSO); green, chunky, no-odor (GCN); green, chunky, odor (GCO)). Asterisks indicate significant differences at the $p < .05$ level.

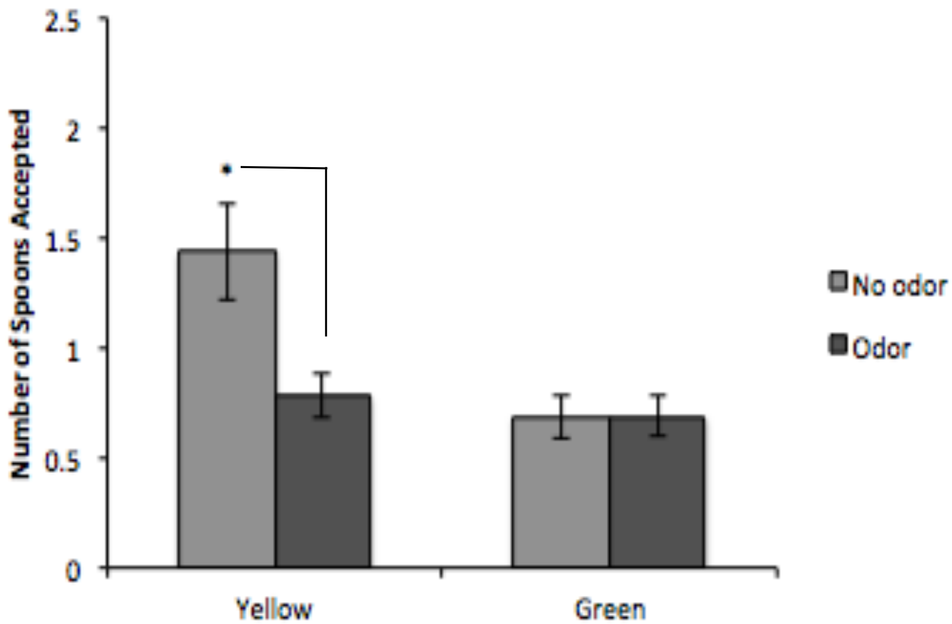
Children's Consumption of the Samples

This analysis revealed a main effect of neophobia, $F(1, 50) = 7.39$, $p < .01$, $\eta^2 = .13$, with neophobic children eating fewer spoons ($M = .18$, $SE = .03$) than non-neophobic children ($M = .31$, $SE = .03$). There was a main effect of color, $F(1, 50) = 21.96$, $p < .01$, $\eta^2 = .31$, such that children accepted more spoons of the yellow ($M = .27$, $SE = .03$) than of the green samples ($M = .21$, $SE = .02$). There was also a main effect of odor, $F(1, 50) = 15.33$, $p < .01$, $\eta^2 = .24$, with children accepting more spoons of the no-odor samples ($M = .27$, $SE = .03$) than of the odor samples (*M* = .22, *SE* = .02). Additionally, there was a marginal main effect of texture, $F(1, 50) = 3.65$, $p = .062$, $\eta^2 = .07$. Children tended to accept more spoons of the chunky (*M* = .26, *SE* = .03) than of the smooth samples (*M* = .23, *SE* = .02).

As shown in Figure 2, there was also a significant interaction between color, texture, and odor, $F(1, 50) = 6.20$, $p < .05$, $\eta^2 = .11$. When we broke this interaction down by texture, there was a main effect of color for the smooth samples, $F(1, 51) = 17.47$, $p < .001$, such that children accepted more spoons of the yellow (*M* = .26, *SE* = .03) than of the green (*M* = .19, *SE* = .02) smooth samples. There was also a main effect of odor, $F(1, 51) = 8.00$, $p < .01$, such that children accepted more spoons of the no-odor (*M* = .25, *SE* = .03) than of the odor (*M* = .20, *SE* = .02) smooth samples. Additionally, there was a color x odor interaction for the smooth samples, $F(1, 51) = 11.65$, $p = .001$. When we broke this interaction down by color, we found that children consumed more of the yellow, smooth, no-odor samples (*M* = .31, *SE* = .03) than of the yellow, smooth, odor samples (*M* = .21, *SE* = .02). However, there was no significant difference between the green, smooth, no-odor (*M* = .19, *SE* = .03) and odor (*M* = .19, *SE* = .02) samples.

For the chunky samples, there was a main effect of color, $F(1, 51) = 5.59$, $p < .03$, such that children accepted more spoons of the yellow, chunky (*M* = .27, *SE* = .03) than of the green, chunky (*M* = .23, *SE* = .03) samples. There was also a main effect of odor, $F(1, 51) = 4.23$, $p < .05$, such that children accepted more spoons of the chunky, no-odor (*M* = .27, *SE* = .03) than of the chunky, odor (*M* = .23, *SE* = .03) samples. There was no color x odor interaction for the chunky samples.

A. Smooth Samples



B. Chunky Samples

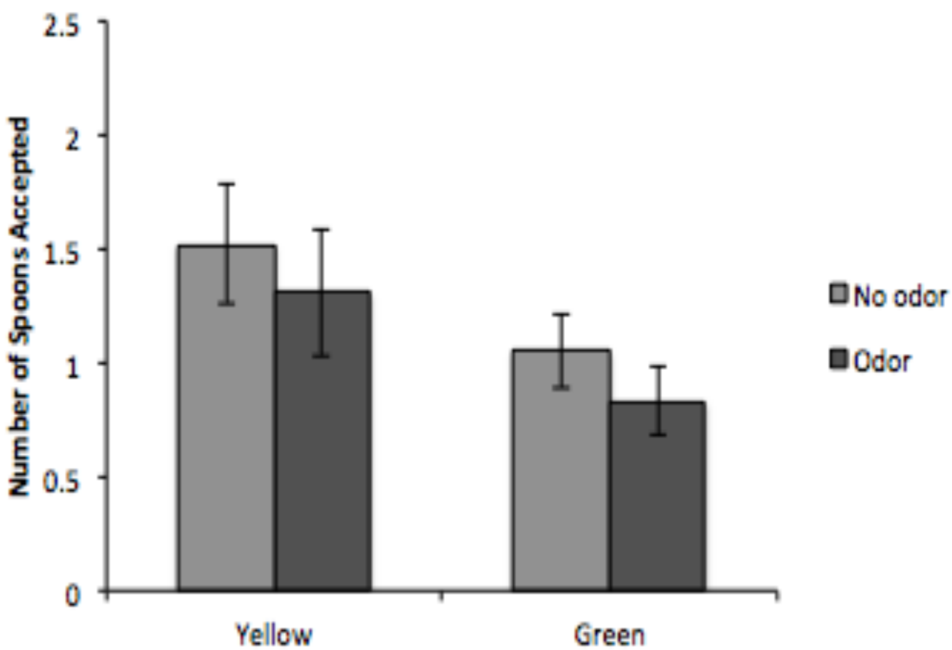
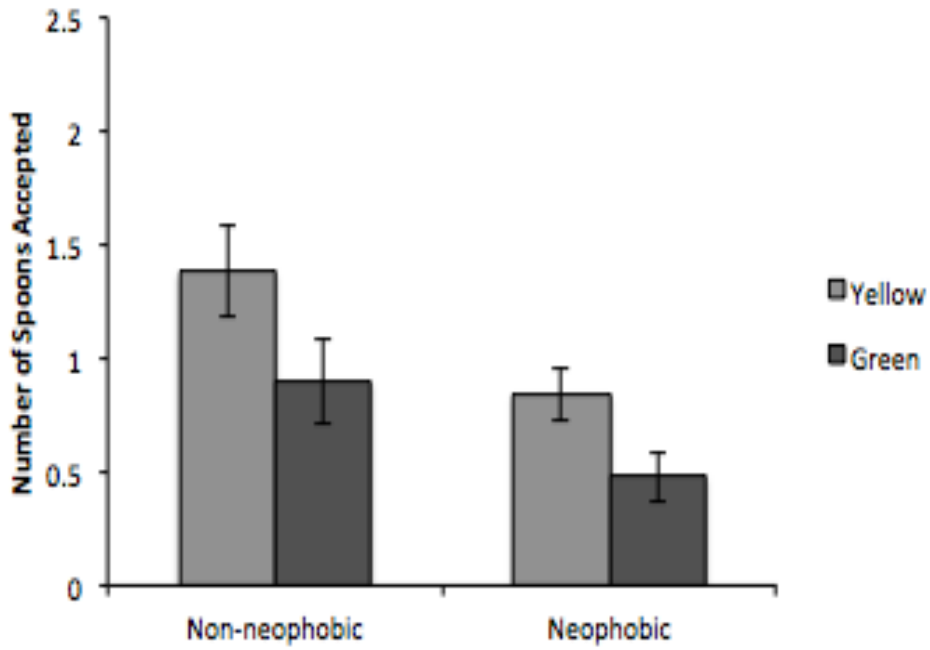


Figure 2. Children's consumption (non-transformed means) of the smooth (A) and chunky (B) samples as a function of their color (yellow, green) and odor (no-odor, odor). The asterisk refers to a significant difference in number of spoons accepted at the $p < .01$ level.

Additionally, there was a marginal significant interaction between color, texture, and neophobia, $F(1, 50) = 2.99$, $p = .09$, $\eta^2 = .06$, as shown in Figure 3. We broke this interaction down by texture. For the smooth samples, we found a main effect of color, $F(1, 51) = 15.17$, $p < .001$, such that children accepted more spoons of the yellow, smooth ($M = .28$, $SE = .03$) than of the green, smooth ($M = .20$, $SE = .02$) samples. There was also a main effect of neophobia, $F(1, 51) = 6.42$, $p < .02$, such that the neophobic children accepted fewer spoons ($M = .18$, $SE =. 03$) than the non-neophobic children ($M = .29$, $SE = .03$). For the chunky samples, there was a main effect of color, $F(1, 51) = 7.83$, $p < .01$, such that children accepted more spoons of the yellow, chunky (M = .29, SE = .03) than of the green, chunky ($M = .24$, $SE = .03$) samples. Additionally, there was a main effect of neophobia, $F(1, 51) = 6.83$, $p < .01$, such that neophobic children accepted fewer spoons of the chunky samples ($M = .19$, $SE = .04$) than the non-neophobic children ($M = .34$, $SE = .04$). There was also a significant color x neophobia interaction, $F(1, 51) = 6.68$, $p < .02$, which we broke down by color. We found that the non-neophobic children accepted more spoons of the yellow, chunky ($M = .40$, $SE = .05$) than of the green, chunky ($M = .28$, $SE = .04$) samples, whereas the neophobic children did not differ in their consumption of the yellow, chunky ($M = .19$, $SE = .04$) and green, chunky ($M = .19$, $SE = .04$) samples.

A. Smooth Samples



B. Chunky Samples

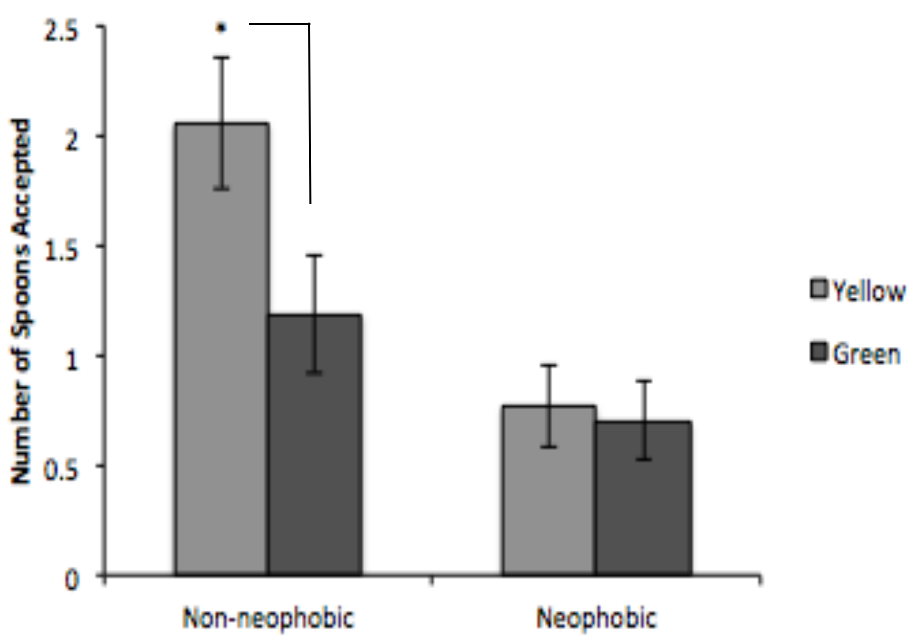


Figure 3. Children's consumption (non-transformed means) of the smooth (A) and chunky (B) samples as a function of their color (yellow, green) and the child's neophobia (non-neophobic or neophobic). The asterisk refers to a significant difference in number of spoons accepted at the $p < .05$ level.

Discussion

The goal of this study was to examine the individual and interactive effects of the color, texture, and odor characteristics of cream-based vegetable soup samples on three to six year-old children's willingness to try and consumption of this food. Results showed that children who were more neophobic rated the samples less positively, were less willing to try the samples, and consumed fewer spoons of each sample than those who were non-neophobic. With respect to the effects of the color, texture, and odor of the samples, children's responses varied according to the measure collected. While color played an important role in children's hedonic ratings, color and texture interacted to affect neophobic children's willingness to try the samples. Finally, all three factors interacted to affect children's consumption of the samples. Below we further discuss the findings revealed by each of these measures.

Children's Dietary Habits

Based on parental reports, although consumption of green and cruciferous vegetables was low (each consumed about 3 times a week), we found that neophobic children were significantly less likely than non-neophobic children to have tried or regularly consume a variety of green and cruciferous vegetables. It is likely that these dietary habits are associated with those of the children's parents. This was supported by the finding that parental neophobia was positively correlated with children's neophobia. Parental neophobia was also negatively correlated with measures of child vegetable consumption in our study. These findings suggest that neophobic parents may contribute to their children's neophobic eating behaviors by infrequently exposing them to green and cruciferous vegetables.

Children's Hedonic Ratings of the Samples

When we analyzed children's hedonic ratings prior to trying the samples, we found that they rated the yellow samples more positively than the green samples. This suggests that the visual cue of color, rather than the visual cue of texture or the odor of the food, may primarily drive children's expectations about whether they will like a food. In line with these findings, Poelman and Delahunty (2011) found that color was related to hedonic ratings prior to trying vegetables. It has been suggested that around the time that children start categorizing foods (Nguyen & Murphy, 2003), they begin to develop schemata about how acceptable foods look and begin to accept or reject these foods based on these beliefs (Dovey et al., 2008). Pliner (2008) proposed that children's schemata may serve as an underlying mechanism for rejection of novel foods because of a negative bias against unfamiliar foods. It may also be the case that novel foods are inconsistent with children's positive mental representations of familiar, well-liked foods (Dovey et al., 2008). Furthermore, these schemata may be largely appearance-related (Pliner, 1994). Because young children use color when categorizing foods (Macario, 1991; Rioux, Picard, & Lafraire, 2016), it is likely that color contributes to the development of children's food-related schemata and they utilize this information when forming judgments about whether they will like a novel food.

It is therefore possible that the children associated the yellow color with yellow and orange vegetables, which are typically sweeter and starchy (e.g., corn, carrots, and sweet potatoes) and as a result are typically better liked (Søndergaard & Edelenbos, 2007). On the other hand, children may have associated the green color with vegetables that are generally disliked by young children, such as brassica vegetables (e.g., broccoli, Brussels sprouts, cabbage, and kale), which are often green in color (Søndergaard & Edelenbos, 2007). Our findings further suggest that neophobic and non-neophobic children expect to like yellow foods more than green foods.

Children's Willingness to Try the Samples

Our analyses of children's willingness to try the samples suggest that for the majority of samples (75%), neophobic children were less likely than non-neophobic children to try. This aligns with definitions of neophobia (Dovey et al., 2008), since corn chowder was an unfamiliar food for many children in this study. One potential explanation for these differences stems from research suggesting that neophobic and non-neophobic individuals differ in their hedonic judgments of various odors, as well as in their sniffing behaviors (Raudenbush, Schroth, Reilley, & Frank, 1998). Compared to neophobic individuals, non-neophobic individuals not only rate odors as more pleasant, but also they also take bigger sniffs when asked to smell an odor (Raudenbush et al., 1998). Furthermore, non-neophobic individuals have been shown to perform better than neophobic individuals on odor identification tasks (Demattè et al., 2013). Therefore, children's experience of the sample odors in this study may have differed as a function of their neophobia and may have differentially influenced their willingness to try the samples.

The only two types of samples for which we did not see a significant difference between neophobic and non-neophobic children's willingness to try were the green, chunky samples. This occurred regardless of their odor and may be in part due to the their unique appearance (i.e., the color combined with the texture). Unlike the other six samples, these two samples contained yellow kernels of corn in a green soup base. Therefore, the corn may have been especially salient and served as a source of familiarity to the children. While neophobic children were significantly less likely than non-neophobic children to try the other samples, the ability to visually identify one familiar aspect of the food may have made the neophobic children more willing to try the green, chunky samples. Thus, although these samples appeared to have a "lumpy" or chunky texture, which is thought to deter children's consumption (Werthmann et al., 2015), neophobic children more readily tried these samples likely because they recognized the corn – a generally well-liked vegetable. This finding expands upon previous findings with adults demonstrating that adding familiar elements to novel foods increases individuals' willingness to try them (Stallberg-White & Pliner, 1999).

Children's Consumption of the Samples

Overall, neophobic children accepted fewer spoons of the samples than non-neophobic children in this study. This supports findings that neophobic children are not only less likely to try novel foods compared to non-neophobic children (Coulthard et al., 2016), but also that they are less likely to continue to consume these novel foods once they have tried them. Research suggests that this may occur because neophobic children tend to like vegetables less than non-neophobic children (Donadini et al., 2012).

Regardless of neophobia, each of the sensory characteristics of the samples independently influenced children's consumption, which is in line with previous research (Donadini et al., 2012; Poelman & Delahunty, 2011; Zeinstra et al., 2010). As we hypothesized, children ate more of the yellow samples than of the green samples and more of the no-odor samples than of the odor samples. Despite the fact that the samples did not have the bitter taste that is typical of green vegetables, the green color and the green vegetable odor may have negatively affected children's expectations of the flavor of the food, which in turn may have lowered their consumption. In support of this, Zeinstra et al. (2010) found that green color is negatively associated with young children's liking of French beans. However, contrary to our predictions, children tended to accept more spoons of the chunky samples than of the smooth samples. As previously discussed, this may be because the kernels of corn served as a source of familiarity, influencing children's willingness to try the novel samples (Stallberg-White & Pliner, 1999) and promoting further consumption of them.

As we hypothesized, we also found that the color, texture, and odor of the samples interacted to influence children's consumption. In general, children consumed more of the chunky samples than of the smooth samples, however, the pattern of consumption for the smooth and chunky samples differed. Children consumed significantly more of the yellow, smooth, no-odor (YSN) sample than the yellow, smooth, odor (YSO) sample. In contrast, for the chunky samples, consumption of the yellow samples did not differ as a function of the presence of the green vegetable odor. In fact, children consumed similar amounts of the YSN sample relative to the chunky samples. This may have been because the YSN sample had two "positive" or well-liked characteristics (yellow color and no added odor) and only one "negative" attribute (smooth texture), like most of the chunky samples (except the GCO sample).

Overall, it appeared that the negative sensory attributes were additive. For example, children consumed more of the yellow, chunky, no-odor sample (zero negative attributes), than of the chunky samples that had only one negative attribute. In turn, they consumed even less of the green, chunky, odor sample (two negative attributes). However, for the smooth samples (most of which had two or more negative attributes), consumption was at a floor; children on average consumed less than one spoon of food. Given that green color and the green vegetable odor are associated with the consumption of green vegetables, which are often bitter and disliked by children (Bell & Tepper, 2006; Søndergaard & Edelenbos, 2007; Turnbull & Matisoo-Smith, 2002), it is not surprising that the presence of either or both of these sensory cues deterred children from consuming the smooth samples. Furthermore, it is logical that the presence of the familiar corn kernels in the samples overshadowed the negative effects of the green color or green vegetable odor.

Our analyses also revealed a marginal interaction between color, texture, and neophobia. We found that although neophobic children's consumption was low for all of the samples, it was especially low for the green, smooth samples, which had at least two negative attributes and did not contain any familiar elements (i.e., corn kernels). For the chunky samples, non-neophobic children accepted significantly more spoons of the yellow than of the green samples; however, this was not the case for the smooth samples. This suggests that for non-neophobic children, the influence of color is moderated by the texture of the sample. For neophobic children on the other hand, the color did not influence consumption of the samples. It is possible that because non-neophobic children have had more extensive food exposure, they recognized the yellow, chunky samples as "corn chowder," and thus were more accepting of it.

Limitations and Future Directions

This study had several limitations that should be noted. First, our sample consisted of predominantly white children of a healthy BMI from an affluent suburban area. These children may also have had greater access to healthy foods, including fruits and vegetables. Therefore, the results of this study are limited in their generalizability.

Additionally, the yellow, smooth, no-odor (YSN) sample was consistently presented first to the children. This was done because we expected this sample to be better liked than the other samples, and thus thought it would encourage children to continue participating. Although this may have influenced our data on children's acceptance of the samples, when we assessed whether children consumed more of the YSN samples than the other seven samples, we found no difference in the number of spoons they accepted. Therefore, it is unlikely that children were more likely to accept the YSN samples because they were presented first.

Although we asked about children's familiarity with cream-based soups, parents were not asked if their child had tried corn chowder specifically or if they liked corn chowder before participating in the study. Therefore, it cannot be said with certainty that the corn chowder was completely novel to all children who participated, and the degree to which familiarity with the chowder influenced the amount consumed cannot be ascertained. Additionally, the taste of the smooth samples differed slightly from the chunky samples. Because we added additional corn to the chunky samples to ensure the children viewed the texture of the smooth and chunky samples as different, we blended the same amount of corn into the smooth samples in an attempt to control the taste. However, because blending released some of the natural sweetness of the corn, the children may have perceived the smooth samples as slightly sweeter than the chunky samples. Despite the sweeter taste of the smooth samples, however, children did not consume more of these relative to the chunky samples.

Future work should use different methods to assess behavioral aspects of neophobia, beyond hedonic ratings prior to trying and willingness to try. Especially with young children, hedonic ratings should be interpreted cautiously (Forestell & Mennella, 2017). Follow-up studies should therefore examine continuous variables, such as children's hesitancy to try the samples. Additionally, facial analysis could be done to examine children's liking of the samples (e.g., Forestell & Mennella, 2007). This would provide greater insight into the sensory properties that might impact children's willingness to try novel vegetables, and it may reveal important differences between neophobic and non-neophobic children.

Follow-up studies should also utilize different vegetables in the behavioral task to determine if these findings accurately depict neophobic behavior towards vegetables in general. However, this may prove difficult to do. Corn chowder was utilized in the present study primarily for ease of manipulation, but also for compliance purposes. Many children who participated in this study refused to try one or more samples, so using a more disliked vegetable may lead to difficulties collecting data.

Conclusions

This study was the first to use a controlled experimental design to examine the relative and interactive effects of color, texture, and odor on children's responses to novel food samples as a function of their food neophobia. Research suggests that in addition to exposing infants to a variety of flavors (Gerrish & Mennella, 2001), familiarizing them with the appearance, texture, odor, and sounds of a novel fruit or vegetable may facilitate acceptance (Dazeley & Houston-Price, 2015). This may occur, in part, because children incorporate familiar sensory cues into their food-related schemata. Consistent with the results of the current study, it may be particularly difficult to promote acceptance of vegetables in neophobic children because they are less likely to try (Coulthard et al., 2016), like (Donadini et al., 2012) and accept vegetables (Cooke et al., 2006) compared to non-neophobic children, possibly as a result of a negative bias associated with novel foods (Pliner, 2008).

Pliner (2008) suggests that it is important to ensure that children's first exposures to foods are positive, to avoid developing a negative bias towards novel foods, which may later be difficult to overcome. Therefore, exposure strategies to encourage initial sampling of a novel food should consider utilizing familiar sensory characteristics, such as familiar colors, textures, or odors, to facilitate acceptance. This may be an important step in successfully exposing children to a wider variety of vegetables at a young age, and thus building up children's food-related schemata.

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Appendix A

Food Neophobia Scale

Instructions: Please read the following statements carefully and circle the appropriate responses using the scale below:

1 - Extremely Disagree	5 - Slightly Agree
2 - Very Much Disagree	6 - Very Much Agree
3 - Slightly Disagree	7 - Extremely Agree
4 - Neither Agree Nor Disagree	

1. I am constantly sampling new and different foods……….. 1 2 3 4 5 6 7
2. I don't trust new foods……………………………………. 1 2 3 4 5 6 7
3. If I don't know what is in a food, I won't eat it…………... 1 2 3 4 5 6 7
4. I like foods from different countries……………………… 1 2 3 4 5 6 7
5. Ethnic food looks too weird to eat……………………….. 1 2 3 4 5 6 7
6. At dinner parties I will try a new food……………………. 1 2 3 4 5 6 7
7. I am afraid to eat things I have never had before…………. 1 2 3 4 5 6 7
8. I am very particular about the foods I will eat……………. 1 2 3 4 5 6 7
9. I will eat almost anything…………………………………. 1 2 3 4 5 6 7
10. I like to try new ethnic restaurants.……………………….. 1 2 3 4 5 6 7

Appendix B

Food Neophobia Scale - Child Version

Instructions: Please answer the following questions using the scale below:

1 - Completely Disagree

2 - Slightly Disagree

3 - Neither Agree Nor Disagree

4 - Slightly Agree

5 - Completely Agree

1. My child is afraid to try new foods……………………………… 1 2 3 4 5
2. My child likes foods from different countries………………….... 1 2 3 4 5
3. My child will eat almost anything……………………………….. 1 2 3 4 5
4. My child constantly wants to try new food……………………… 1 2 3 4 5
5. My child does not trust new foods………………………………. 1 2 3 4 5
6. If my child does not know the food, he/she won't try it…………. 1 2 3 4 5

Appendix C

Food Frequency Questionnaire - Child

Instructions: We would like to hear from you about the types of foods **your child** usually eats. For each food, we will ask to indicate how often (per day or per week) **your child** consumes the food. If the food is something your child does not eat or does not like, you may let me know. If your child does not eat the food because of allergies or personal beliefs, please let me know that as well. Think about these foods based on the last few months.

1. Does your child like this food?

   Yes No Never tried

2. How often do you offer your child this food?

   0 - Never
   1 - Less than once a week
   2 - Once a week
   3 - Twice a week
   4 - Three times a week
   5 - Four times a week
   6 - Five times a week
   7 - Six times a week
   8 - Everyday
   9 - More than once a day

3. How often does your child accept this food?

   0 – Never
   1 – Less than once a week
   2 – Once a week
   3 – Twice a week
   4 – Three times a week
   5 – Four times a week
   6 – Five times a week
   7 – Six times a week
   8 – Everyday
   9 – More than once a day

4. How do you typically prepare this food for your child?

   1 - Cooked/grilled
   2 - In soup or stew
   3 - Raw
   4 - Stir fry/casserole
   5 - Stuffed
   6 - Other

Appendix D

Foods Used in Child Food Frequency Questionnaire

1. Arugula
2. Asparagus
3. Bell pepper
4. Broccoli
5. Brussels sprouts
6. Cabbage
7. Carrots
8. Cauliflower
9. Celery
10. Collard greens/kale
11. Corn
12. Eggplant
13. Green beans
14. Okra
15. Peas
16. Potatoes
17. Spinach
18. Squash
19. Sweet Potatoes
20. Tomatoes
21. Turnips
22. Zucchini